Infiltration Protocol

Purpose

To determine the rate at which water soaks into the ground as a function of time.

Overview

Two nested cans are pushed into the soil and water is added to both to a depth of at least 5 cm. The time it takes water to drop a fixed 2 - 4 cm interval is recorded and the measurement is repeated. Infiltration measures how easily water moves vertically through the soil and this can indicate how flood-prone an area is.

Time

One class period to build and test the double-ring infiltrometer

45 minutes or one class period for the measurement

This protocol can be done while samples are collected for the Gravimetric Soil Moisture

Level

All

Frequency

Three or four times a year at the Soil Moisture Study Site

One time at a Soil Characterization Sample Site

In all cases three sets of measurements should be taken within a radius of 5 m.

Key Concepts

Infiltration rate changes depending upon the level of soil saturation.

If water is not stored in the ground, it must evaporate or runoff and may pool on the surface for a time.

Skills

Building an infiltrometer
Testing
Organizing
Observing
Monitoring time intervals
Recording data
Analyzing data

Materials and Tools

Two metal rings the smaller with a diameter of 10 - 20 cm and the other with a diameter roughly 10 cm larger (Coffee cans work!)
Buckets or other containers to transport a total of at least 8 L of water to the site
Ruler
Waterproof marker
Stop watch or watch with a second hand
Block of wood
Hammer
One soil sample container suitable for soil moisture measurement
Grass clippers
Funnel

Prerequisites

None

Background

Infiltration rate is determined by measuring the time it takes the level of water sitting on a soil to drop a fixed distance. This rate changes with time as the soil pore space fills with water and reaches a steady rate, characteristic of water flow through your soil when it is *saturated*. There are three flow regimes you might encounter:

Unsaturated flow - the initial flow rate is high as the dry soil pores fill with water.

Saturated flow - the flow rate is steady and water moves into the soil at a rate determined by soil texture and structure.

Ponding - the flow rate approaches zero when the ground becomes totally saturated and is no longer able to conduct water through its pores.

Preparation

Site selection

Select a location within 2 - 5 m of the Soil Moisture Study Site or of a Soil Characterization Sample Site. Be careful that you do not leave a hose running where the water will flow over your soil moisture sampling points!

Construct a Dual Ring Infiltrometer

Cut the bottom out of your cans.

Use a permanent waterproof marker or paint to partially shade a ring on the inside of the smaller can to use as a timing reference mark. The vertical width should be 20-40 mm and centered roughly 9 cm from the bottom of the can. Many cans have impressed ribs that make good reference marks but it is still necessary to mark them for good visibility.

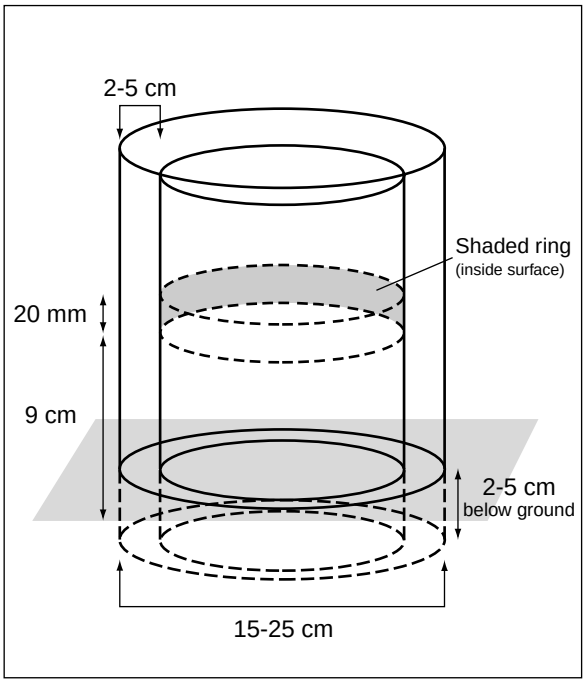
Measure and record the vertical width of your reference band (in mm).

Measure and record the widths of your inner and outer rings (in cm).

Timing

You can use either a stop watch or a watch with a second hand to time the water flow into the soil. When using a stop watch, start it as water is first poured into the inner ring and read elapsed time from it for each start time and end time.

Figure SOIL-P-14: Double-ring Infiltrometer



Practice

Have students practice this protocol, including the timing, so that they become comfortable making the measurements at a site where there is easy access to water and at a time when they can start over and do not have to complete a full 45 minute set of measurements. If students practice in a sandy location, the infiltration time intervals will be shorter and they will get more chances to make measurements.

How to Measure Infiltration

1. Clip any vegetation (grass) to the ground surface and remove all loose organic cover over an area just larger than your largest can. Try not to disturb the soil.
2. Starting with the smaller can, twist the cans 2 - 5 cm into the soil. A hammer may be used to pound the can into the surface. If you must use a hammer, a block of wood should be used between the hammer and the top of the can to distribute the force of the hammering. Do not hammer so hard that the can crumples.
3. Measure the height above ground level of the bands you marked on the inside of the smaller can.

4. As quickly as possible, do the following, using a team of 3 - 4 students:
   4.1. Pour water into both rings, and maintain a level approximately equal to the level in the inner ring. Note that the water level in the outer ring tends to drop more quickly than that of the inner ring.
   4.2. Pour water into the inner ring, to just above the upper reference mark.
   4.3. Start the stopwatch or note the time to the second and record it on the Infiltration Data Work Sheet.
   Note: The outer ring should not be leaking water to the surface around its rim. If it is, start over in another location, push the outer ring deeper into the soil or pack mud around its base.
5. As the water level in the inner can reaches the upper reference mark, record the elapsed time as your start time.
6. During the timing interval, keep the water level in the outer ring approximately equal to the level in the inner ring, but be careful not to pour water into the inner ring (using a funnel can help) or to let either ring go dry.
7. As the water level in the inner can reaches the lower reference mark,
   7.1. Record the time as your end time.
   7.2. Figure the time interval by taking the difference between the start and end times.
   7.3. Pour water into the inner ring to just above the upper reference mark. Raise the water level in the outer ring so that they are approximately equal.
8. Continue repeating steps 5 - 7 for 45 minutes or until two consecutive interval times are within 10 sec. of one another.
9. Some clays and compacted soils will be impervious to water infiltration and your water level will hardly drop at all within a 45-minute time period. In this case, record the depth of water change, if any, to the nearest mm. Record the time at which you stopped your observations as the end time. Your infiltration measurement will consist of a single data interval.
10. Remove the rings.
11. Measure the near-surface (0 - 5 cm depth) soil moisture from the spot where you just removed the rings. Follow the Gravimetric Soil Moisture Protocol.
12. Make two other infiltration measurements within a 5 m diameter area, either at the same time using other groups or over several days (if it does not rain and change near-surface soil water content). It is not critical that multiple runs have the same number of reading sets, but do not submit runs that are incomplete (e.g. A run that was cut short due to lack of time). If you make more than three sets of measurements, submit your three best sets.

Data Analysis and Presentation

Infiltration rate is found from the distance that the water level decreased divided by the time required for this decrease. For your GLOBE measurements this is equal to the vertical width of your reference band divided by the difference between the start and end times for an interval.

Use the Infiltration Data Work Sheet to record and help calculate the values needed to plot your results. The flow rate we observe for each timing interval is really the average value during that interval. It is best to record that flow rate at the *midpoint* of the interval times. Infiltration should decrease with time and it is important that you keep track of the *cumulative* time since water was first poured into the inner ring. Look over the table and graph below and make sure that you can use the formulas on the Data Work Sheet to calculate these values before analyzing your own data.

Figure SOIL-P-15
Infiltration into Jim's Garden

Water Level Change = 20 mm

Time						Flow
Start		End		Interval	Midpoint	Cumulative	Rate
[min]	[sec]	[min]	[sec]	[min]	[min]	[min]	[mm/min]
31	00	32	00	1.00	31.50	0.50	20.0
32	30	34	15	1.75	33.38	2.38	11.43
34	30	36	45	2.25	35.62	4.62	8.89
37	15	40	00	2.75	38.62	7.72	7.27
40	45	44	00	3.25	42.38	11.38	6.15
44	15	47	45	3.50	46.00	15.00	5.71
48	15	52	00	3.75	50.12	19.12	5.33
52	15	56	15	4.00	54.25	23.25	5.00
56	30	00	30	4.00	58.50	27.50	5.00

Figure SOIL-P-16: Infiltration